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→ 2x10 MUX test ADR
→ Multiplexing 8 microcalorimeters
→ Surface-micromachined arrays
→ Noise reduction with new pixel geometries

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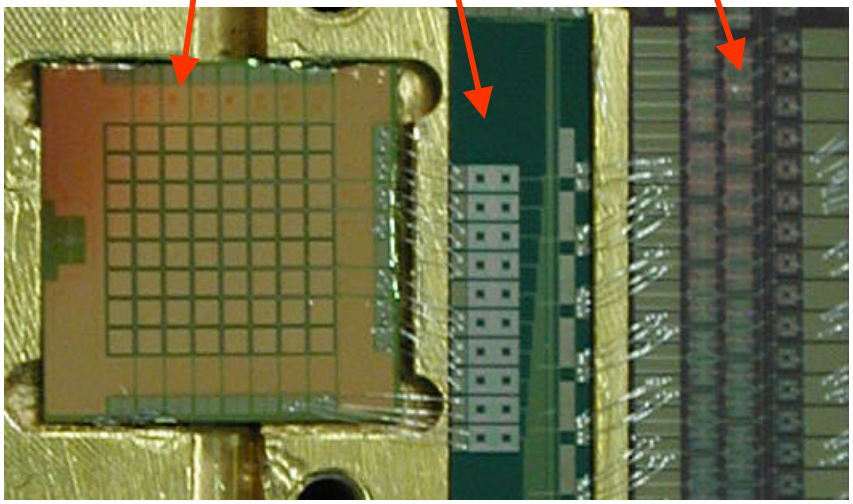
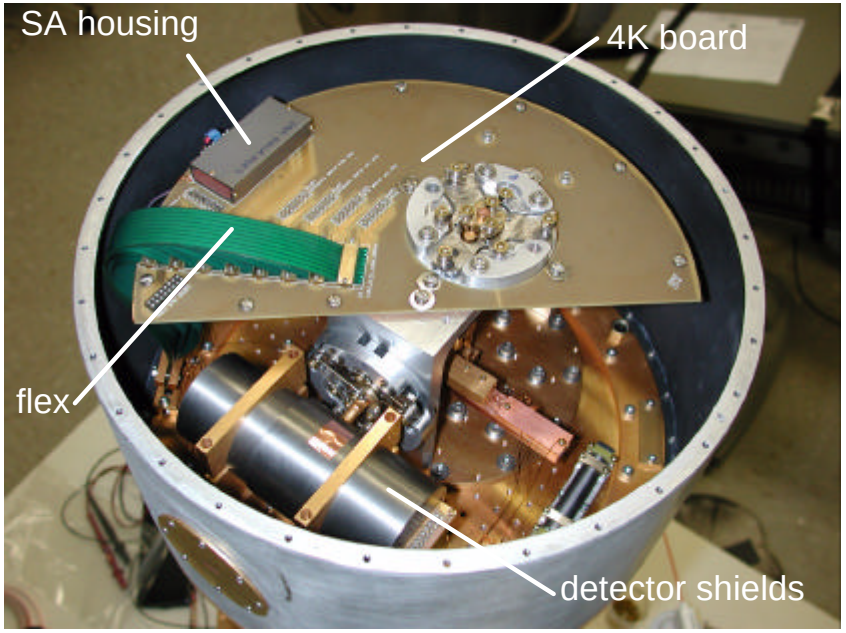
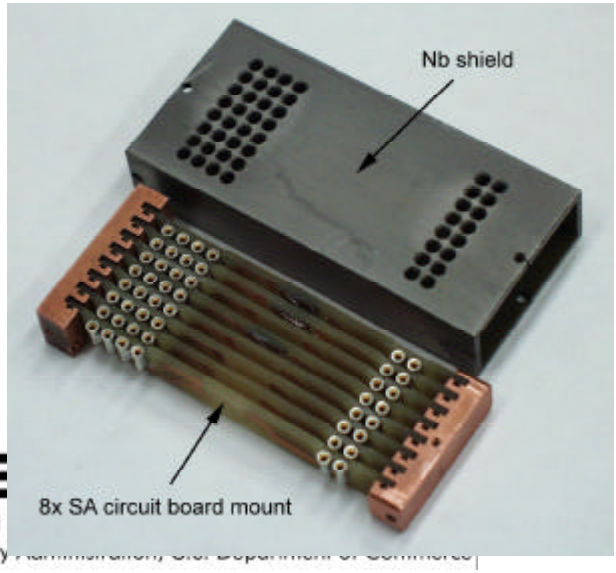
2x10 Multiplexed Test Facility

8×8 µcal array filter chip MUX chip







National Technology

Multiplexing 8 microcalorimeters

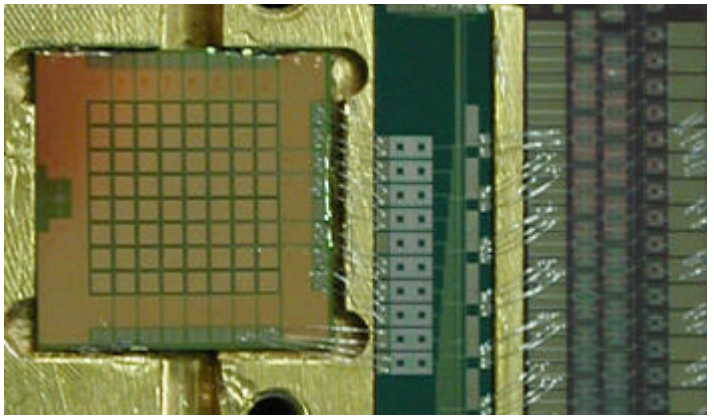
→8 μcalorimeters multiplexed in our "2 × 10" test facility from one 8 × 8 microcalorimeter array.

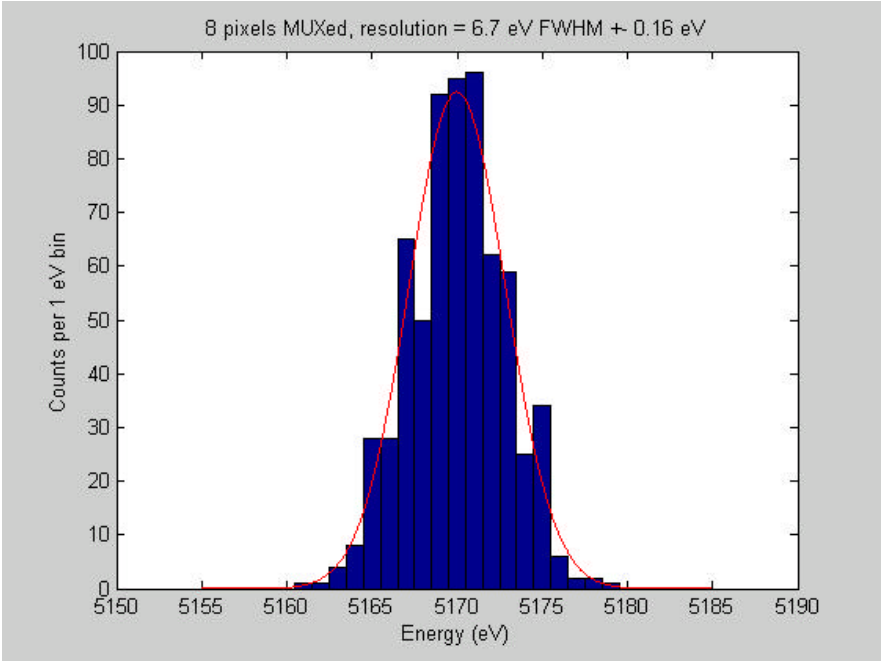
→ Tests were done with Joule heating pulses. X-ray tests are now underway.

→ No statistically significant degradation in energy resolution was seen for 8 multiplexed pixels.

- 6.4 +- 0.2 eV for 2 pixels
- 6.7 +- 0.2 eV for 4 pixels
- 6.7 +- 0.2 eV for 8 pixels

→ Inductive filter limited risetime to ~ 35 μs. Compatible with response time >= 200 μs.





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Performance target for multiplexer

For Constellation-X, significant improvements in amplifier / MUX performance are targeted to achieve 32 pixels multiplexed per output channel:

- Individual SQUID noise improved from 0.5 $\mu\Phi_0/\sqrt{Hz}$ to ~ 0.1 $\mu\Phi_0/\sqrt{Hz}$.
- *Open-loop* bandwidth of the amplifier chain increased from ~ 3 MHz to ~12 MHz.
- Algorithms to robustly correct for photon arrival time.

Status:

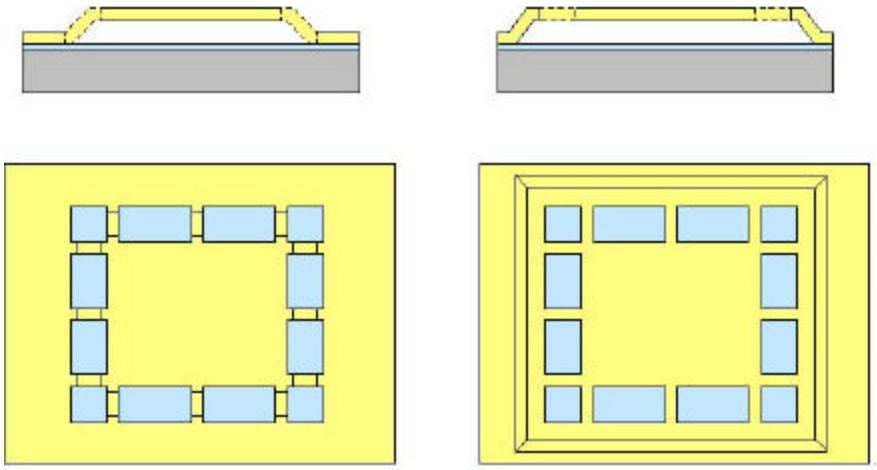
- SQUIDs demonstrated with 0.15 $\mu\Phi_0/\sqrt{Hz}$ white-noise level.
- New designs for SQUID MUX chip, wiring to 4 K, and 300 K preamp now underway.
- Algorithms are being tested.

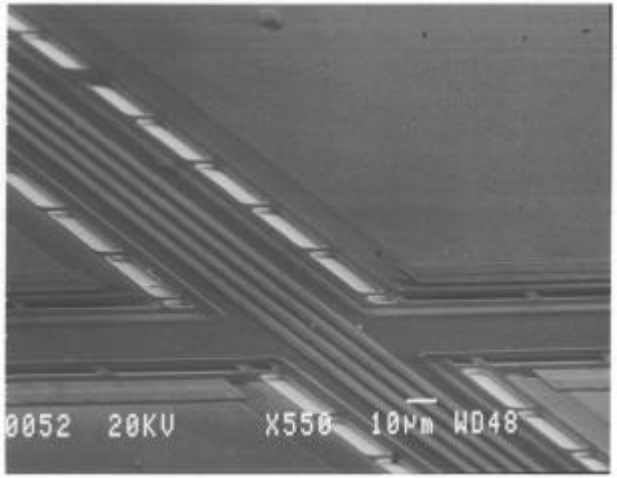
Surface-micromachined μcal arrays

- More room for wiring vs. bulk micromachining, *wafers* more robust.
- New “platform” design vs. old “table leg” design – improved pixel yield
- ~100% yield on pixels without absorbers
- Some pixels with Bi absorbers still fail on cooling

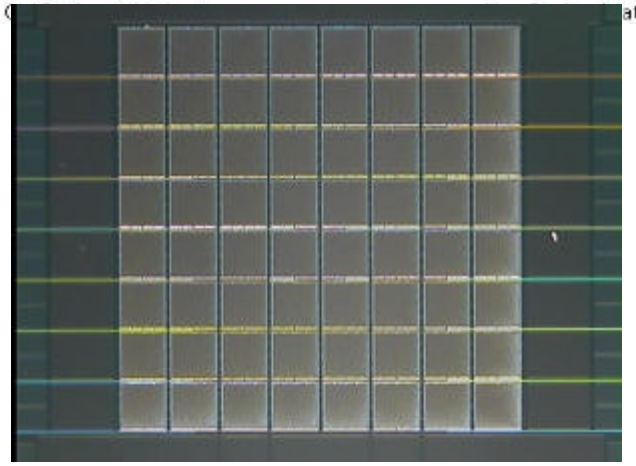
Table legs

platform





SEM image of “platform” design



8×8 array of TES microcalorimeters with 2 μm Bi absorbers

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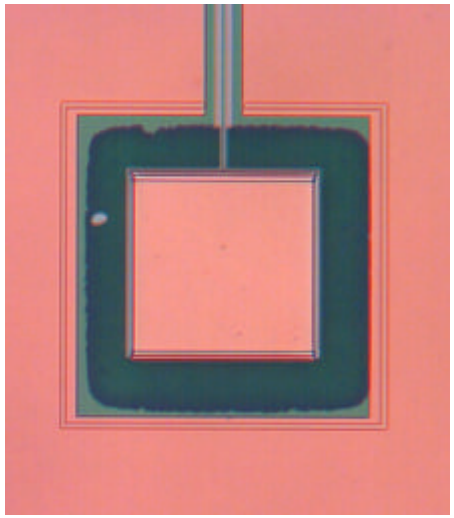
Dependence of Detector Noise on Geometry

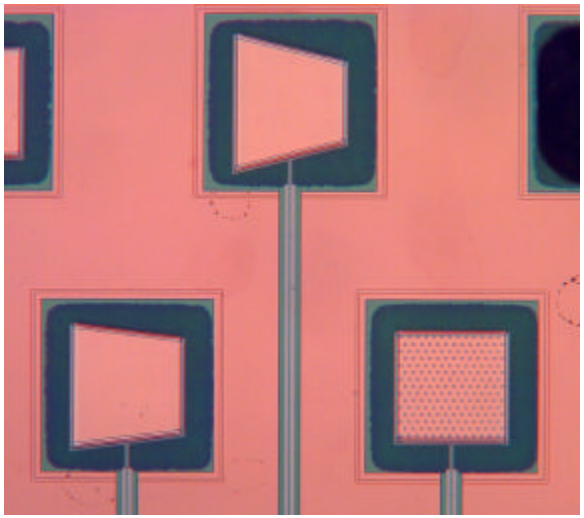
- measure 20 sensors per thermal cycle in multiplexed "2×10" test facility

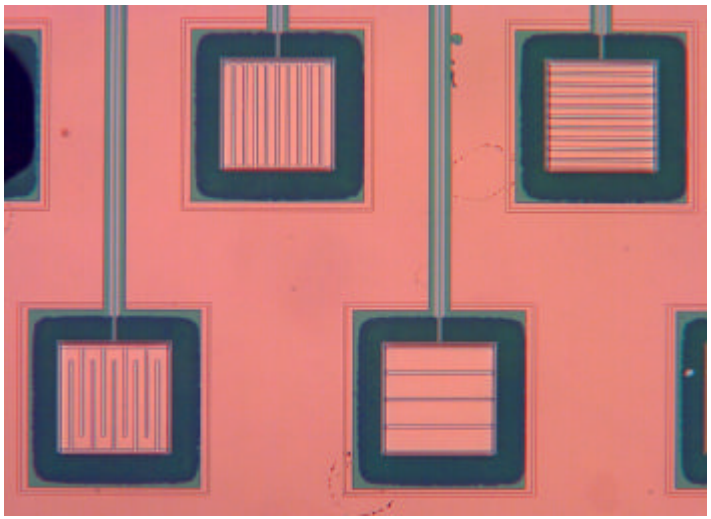
  → greatly expanded testing throughput

- have fabricated devices with various geometries:

  - wedges, normal bars, normal islands, …



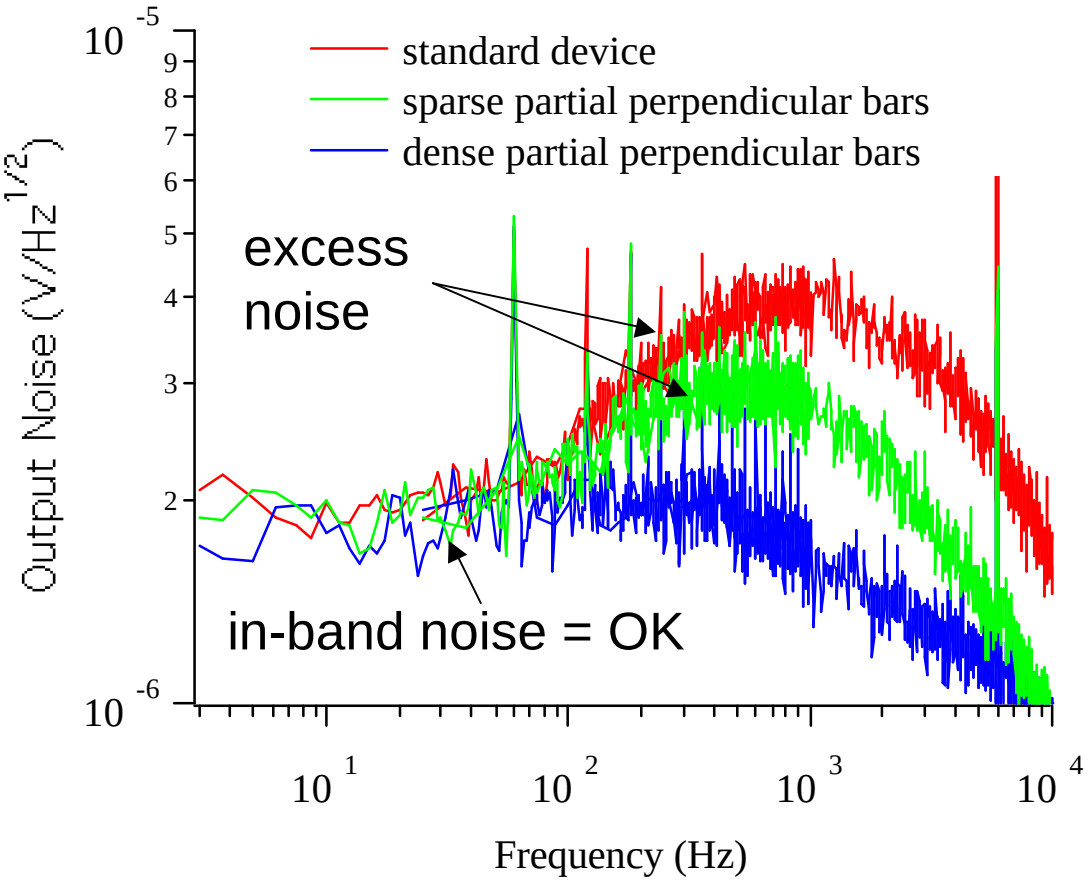




engineer superconducting-normal phase boundary → less noise ?

Demonstrated Noise Reduction

- choose operating point to <u>maximize</u> excess high-frequency noise



- Measurements ongoing
- Some designs have no effect (incl. normal islands)
- Some designs (incl. perpendicular bars) greatly reduce noise, but also reduce α
- Some designs (incl. wedges) modestly reduce noise with little effect on α
- Effect on energy resolution? X-ray tests of promising designs underway.

significant noise reduction possible

Work Plan

- Multiplexing with x-ray signals culminating in “2x8” demo.
- Development of next-generation MUX system, including low-noise and high-bandwidth SQUIDs and room-temperature electronics.
- Optimization of surface-micromachined arrays for robustness, and demonstration of array with Constellation-X form factor and efficiency.
- X-ray illumination of microcalorimeters with new geometries,tests of additional designs, studies of noise mechanisms, and optimization of single pixel for Constellation-X.